AQUATIC AND SEMIAQUATIC VEGETATION OF UTAH LAKE AND ITS BAYS

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ABSTRACT.— Seven aquatic and semiaquatic communities surrounding Utah Lake and its bays are described. Similarities and differences in the community types are discussed. Prevalent species in each type are given. The flora contained 483 species, 150 of which were prevalent enough to be included in the quantitative data analysis. *Distichlis stricta* was the most important and widespread species. Total cover varied in the communities from 10 to 77 percent. Asexual reproduction was shown to increase in importance as moisture in the soil increased. Introduced exotic species were shown to invade most successfully those habitats that show the greatest variability in moisture and/or those that have the greatest internal variation.

Initial comments on the vegetation surrounding Utah Lake were recorded as early as 23 September 1776. Fathers Atanasio Dominguez and Silvestre Velez de Escalante and their party camped on that date adjacent to the southeast shore of the Lake, and it was during their stay that they penned the first known records concerning plant communities in the area. They recorded wide meadows, abundant pasture, and marsh communities on the shores of Utah Lake and noted the prevalence of poplars, willows, flax, and hemp along the streams and east side of the lake (Chevez and Warner 1976). Other early visits were made to the area by trappers, mountain men, and explorers. However, their written records yield little information on the vegetation of Utah Lake that is not extractable from the Dominguez-Velez de Escalante journals. We learn from their writings of occasional bogs, communities containing reeds and abundant marsh grasses, infrequent patches of wild sage, and swamps filled with *Lemna* and *Chara* (Wakefield 1933).

More detailed studies of the plant communities found in and around Utah Lake have been made only in the past 50 years. Cottom (1926) made the first quantitative studies of the vegetation of the lake. He listed 11 formations and 20 associations that he described as making up the vegetation around Utah Lake and adjacent Utah Valley. Wakefield (1937) reported on vegetational changes over a six-year period on the lakeshore south of the present Provo boat harbor. Beck (1942) and Murphy (1951), in conjunction with studies of passerine birds found in the vicinity of the lake, studied and classified the plant communities frequented by the birds on Bird Island and the area from the mouth of Provo River to the south end of the Provo Municipal Airport. Barnett (1964) studied waterfowl habitat at Powell's Slough on the east shores of the lake. He placed the vegetation found there into four major communities based upon habitat type and plant species present. Christensen (1965) studied two *Tamarix ramosissima-Salix amygdaloides* stands near the mouth of the Spanish Fork River and predicted that *ramosissima* (which he understood to be *T. pentrandra*) as a type would eventually replace *Salix amygdaloides* as these trees die. Foster (1968) in a statewide study of the major plant communities of Utah recognized four community types around Utah Lake. His plant community types are broad in definition and based on observation rather than analytical data. Coombs (1970) examined the vascular aquatic and semiaquatic vegetation around the lake and delimited 29 plant communities in 7 major types. Local taxonomic and ecological studies (e.g., Weight 1928, Leichty 1952, Lawler 1960, Bessey 1960, Arnold 1960, White 1963, Skougard 1976) have been of great value by identifying many of the plant species growing in and around the lake.

Even though Utah Lake and its environs is in many localities well studied from the natural history and ecological points of view,

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little has been reported in the literature with regard to (1) man's impact on the plant communities since settlement, (2) the influence and changes wrought by introduced exotic plants, (3) species composition for the major community types, (4) environmental factors influencing the distribution of major community types, (5) community diversity, and (6) information with regard to successional changes and life form patterns along environmental gradients.

Methods

Forty stands of data were selected from the literature (Coombs 1970, Barnett 1964, Christensen 1965) and combined with 10 stands studied by the author in the summer of 1974. Percent sum-frequency values for each species (Phillips 1959), total cover information (Brown 1968), and moisture index values (Coombs 1970) were then assigned to all 50 stands. Percent sum-frequency figures were used to give the species data from the different sources equivalent standing. Where information was questionable and/or lacking (especially with respect to moisture information), supplementary field observations were made in the summer of 1976. Of the stand data taken from the literature only those having relatively complete information were used in this analysis.

Species lists (150 total) were assembled for each stand. Importance values (Warner and Harper 1972) were then computed for each species in relationship to the total vegetative complex and the major communities found in the area. From this information, prevalent species tables were compiled (Tables 4–9). The number of prevalent species included on any one list was equal to the mean number of species reported for the stands of a given community. The prevalents are listed in decreasing order of importance and are the most frequent species in the community; uncommon or rare species are ignored.

Diversity indices (McArthur 1972) were computed from the percent sum-frequency data using the formula:

$$DI = 1/\Sigma\ pi^2$$

where Di is the diversity index and pi is the relative proportion each species contributes to the overall composition of a community.

Ultimately, each stand and/or community was compared to all other stands and/or communities. This process resulted in the production of interstand or intercommunity similarity index values (Ruzicka 1958). A matrix of similarity index values was constructed. The similarity values were clustered by the pair-group clustering procedures described by Sneath and Sokal (1973).

Moisture index data were assigned to each stand using a modification of the methods employed by Coombs (1970). Moisture classes were set up as reported in Table 2.

Floristics and nomenclature follow Cronquist et al. (1977) for the monocotyledons and Holmgren and Reveal (1966) for the dicotyledons.

Results

General Vegetation Descriptions

The aquatic and semiaquatic communities surrounding Utah Lake form a band of vegetation along the lake shore varying in width from 20 m or less on the western shore to 400 m on the eastern shore. In addition, two large bays, Provo Bay and Goshen Bay, extend away from the lake in eastern and southern directions, respectively, and contain a majority of the land area occupied by the aquatic and semiaquatic communities.

During this investigaton 483 plant species were found to be part of the Utah Lake vegetation. Of these, only 150 were of sufficient importance to include in the quantitative data analyses. Only 13 species were included in a prevalence list for the entire area and, as can be seen from Table 1, the list is highly

TABLE 1. The prevalent species found in the vegetation of Utah Lake with their importance value.

Scientific name	Importance value
Distichlis spicata	3364
Scirpus americanus	2587
Eleocharis palustris	2315
Juncus balticus	1832
Carex nebraskensis	1318
Tamarix ramosissima	1094
Scirpus acutus	1039
Hordeum jubatum	1033
Typha latifolia	1030
Lemna minor	945
Sporobolus airoides	662
Salicornia rubra	606
Ambrosia artemisifolia	586

dominated by grasses and sedges, with *Distichlis stricta* being the most important and widespread species.

Seven major vegetative types exist around the Lake (Tables 2 and 3), each occupying unique habitats and each showing varying degrees of internal structure with respect to subcommunity dominants. This subcommunity variation is related in some degree to the prominance of asexual reproduction (by rhizomes) in the dominant species. When dominant species reproduce vegetatitively, large areas may be occupied almost exclusively by a single species or clone even though the abiotic environment is homogenous.

Average values for selected environmental variables are given for the seven major vegetative types in Table 2. It will be seen that the number of stands considered for each community is not equal, varying from 5 to 16. The communities vary with respect to moisture from continuous inundation to seasonal inundation, and finally to those that never experience standing water or high water tables. Communities on the dry end of the

TABLE 2. Selected environmental characteristics of major plant communities surrounding Utah Lake.

Community	ID no.	No. stands considered	Moisture[1] index	Variation[2] in moisture	Exposed surface water	Percent soil exposed	Percent litter cover
Pondweed communities	1	5	1.0	0.0	91.20	0.00	0.00
Bulrush-cattail marshes	2	7	1.0	0.0	26.47	2.51	20.64
Spikerush-bulrush meadows	3	7	1.75	0.26	7.57	5.07	13.02
Grassrush-sedge meadows	4	16	2.13	0.34	1.16	15.52	6.67
Lowland woody communities	5	11	1.86	0.43	23.90	12.53	12.18
Saline terrestrial communities	6	5	3.20	0.34	0.00	72.20	1.90
Annual herbaceous communities	7	4	2.50	0.51	0.00	50.55	20.70

[1]Moisture index is as follows: (1) substratum inundated continuously; (2) substratum seasonally saturated; (3) substratum well drained; (4) substratum dry.
[2]Moisture variability is expressed as a coefficient based on variation on means and standard deviations of moisture index values for individual stands.

TABLE 3. Biotic characteristics of major plant communities surrounding Utah Lake.

	Community Type						
Community characteristic	Pondweed	Bulrush-cattail	Spikerush-bulrush	Grass-rush-sedge	Lowland woody	Saline terrestrial	Annual herbaceous
ID no.	1	2	3	4	5	6	7
$\bar{X}$ no. of species/stand	1	12	17	18	9	5	19
$\bar{X}$ percent living cover	9.8	40.0	74.4	76.6	53.5	26.1	28.8
$\bar{X}$ diversity	0.1	4.1	6.0	6.8	3.31	2.9	10.4
Dominant life form	Aquatic forb	Cattail sedge	Sedge forb	Sedge grass	Shrub	Shrub annual	Annual
Trees	*0.0	0.3	0.2	0.2	13.1	0.0	0.3
Shrubs	0.0	0.3	0.1	0.4	43.4	49.5	3.3
Grasses	0.0	3.3	14.6	28.5	16.1	4.7	8.5
Sedges	0.0	31.3	47.0	40.1	5.5	0.0	4.8
Forbs	100.0	26.8	25.6	21.5	9.1	0.7	22.4
Annuals	0.0	7.8	12.4	9.4	10.5	45.2	60.7
Cattails	0.0	26.5	0.2	0.1	0.3	0.3	0.0
Nonvascular	0.0	3.9	0.0	0.0	0.0	0.0	0.0
Introduced exotics	0.0	1.4	10.7	9.7	38.4	5.4	33.9

*Numbers represent percent relative frequency

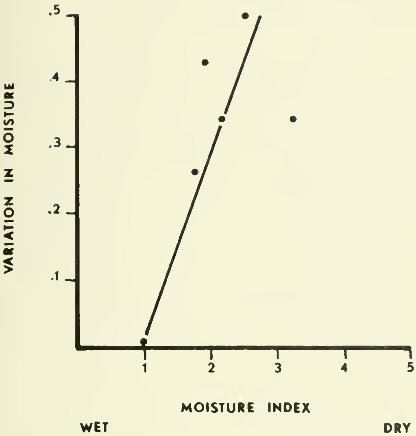

Fig. 1. Variation in moisture in the communities of Utah Lake in relationship to moisture index.

scale exhibit the greatest fluctuations in moisture (Fig. 1). The amount of exposed soil varies among the communities from less than 15 percent to slightly less than 50 percent in the playa and beach communities.

Compositional data for the seven community types is given in Table 3. Each community is dominated by a different set of life-form types, with annuals being especially prevalent in the playa and beach areas. In only two cases do particular life form types become sufficiently abundant to contribute over 50 percent of the plant cover. Generally, the vegetation of the communities considered includes species from several life form classes.

Diversity measurements varied from low values for pond weed communities to high values for the annual herbaceous communities. However, even though the diversity indices varied considerably, no significant correlations could be established between diversity and other parameters.

Similarities between the seven community types are evident since some species show dominance in more than one type (Tables 4–9). To better understand these interrelationships and to assess the degree of uniqueness of the different community types (Tables 2 and 3), a graphical summary of intercommunity similarity is presented (Fig. 2).

TABLE 4. The prevalent species found in the bulrush-cattail marsh communities of Utah Lake with their importance values.

Scientific name	Importance values
Typha latifolia	6814
Lemna minor	6243
Scirpus acutus	5471
Berula erecta	3457
Eleocharis palustris	1771
Spirodela polyrhiza	1257
Riccia fluitans	957
Polypogon monspeliensis	657
Epilobium adenocaulon	614
Lycopus lucidus	314
Nasturtium officinale	300
Scirpus americanus	286

TABLE 5. The prevalent species found in the semiaquatic herbaceous meadow communities of Utah Lake with their importance values.

Scientific name	Importance values
Eleocharis palustris	9229
Carex nebraskensis	4914
Distichlis spicata	2929
Scirpus americanus	2271
Trifolium hybridum	2029
Lycopus lucidus	1629
Scirpus validus	1429
Panicum capillare	1371
Polygonum coccineum	1357
Polygonum amphibium	1100
Iva axillaris	943
Plantago major	943
Ambrosia artemisifolia	800
Agrostis alba	771
Bidens cernua	714
Polypogon monspeliensis	614
Xanthium strumarium	557

In the cluster diagram, communities that are most similar appear close together. The horizontal line connecting any two communities shows the degree of similarity between those entities. Figure 2 demonstrates that each community recognized is highly unlike all other communities considered. The most similar entities are the Spikerush-bulrush meadows and the Grass-rush-sedge meadows, which are only 25 percent similar. Other similarity patterns exist, but the similarity percents are so low that the community types involved can be considered essentially independent of each other.

Community Type Descriptions

Pond Weed Communities

The pond weed communities are continuously inundated by water. They are essen-

TABLE 6. The prevalent species found in the grass-rush-sedge meadow communities of Utah Lake with their importance values.

Scientific name	Importance values
Distichlis spicata	7206
Scirpus americanus	6650
Juncus balticus	5033
Eleocharis palustris	2125
Hordeum jubatum	2113
Carex nebraskensis	1756
Sporobolus aeroides	1588
Glaux maritima	1488
Ambrosia artimisifolia	1156
Potentilla anserina	994
Lycopus lucidus	838
Trifolium hybridum	819
Polypogon monspeliensis	613
Ranunculus cymbalaria	606
Plantago major	606
Iva axillaris	438
Aster brachyactis	381
Suaeda occidentalis	363

TABLE 7. The prevalent species found in the lowland woody communities of Utah Lake with their importance values.

Scientific name	Importance values
Tamarix ramosissima	4573
Salix amygdaloides	2345
Salix exigua	2291
Distichlis spicata	1964
Elaeagnus angustifolia	1809
Hordeum jubatum	1036
Populus fremontii	982
Myriophyllum verticillatum	873
Xanthum strumarium	791

TABLE 8. The prevalent species found in the saline terrestrial communities of Utah Lake with their importance values.

Scientific names	Importance values
Salicornia rubra	6060
Allenrolfia occidentalis	5460
Kochia americana	3840
Sarcobatus vermiculatus	1340
Suaeda nigra	1290

tially monospecific (*Potamogeton latifolius*) types that occupy the open water areas of the lake. No other communities are found at equivalent depths. As a consequence, this community is analytically distinct from all other communities. Stand dimensions in the lake range from about 8 to 400 square feet (the largest being some 40 feet long by 12 feet wide). Stands occur in water as deep as 8

TABLE 9. The prevalent species found in the annual herbaceous communities of Utah Lake with their importance values.

Scientific names	Importance values
Polygonum lapathifolium	5700
Chenopodium glaucum	4100
Xanthium strumarium	3700
Panicum capillare	3700
Sesuvium verrucosum	2150
Malva neglecta	1950
Ambrosia artemisifolia	1900
Scirpus maritimus	1650
Aster frondosus	1550
Verbena bracteata	1450
Distichlis spicata	1450
Polypogon monspeliensis	1100
Sitanion hystrix	950
Rumex crispus	850
Trifolium spp.	850
Sporobolus airoides	800
Tamarix ramosissima	700
Grindelia squarrosa	450
Salix exigua	450
Taraxacum officinale	450
Medicago sativa	450

feet, but depth is variable. Coombs (1970) recorded that in June 1967 David A. White counted 137 stands in the open water of Utah Lake. Stands are found along the shoreline less frequently.

Bulrush-Cattail marshes

The Bulrush-cattail marshes also tolerate continuous inundation. The water depth fluctuates but generally does not exceed 2 feet and is often at ground level. The soil is characterized by considerable organic matter. Stands supported 12 species on the average but were dominated by *Typha latifolia* and *Scirpus acutus* (Table 4). In general appearance, this type appears somewhat like a giant jigsaw puzzle, with the major dominants growing in dense monospecific stands and overlapping with each other in only narrow zones. Along their edges and in areas where the cover is more open, one finds more mixing of the dominant species and increased species diversity. It is in these more open areas that many of the subdominant species (Table 4) are found.

The community occurs in three major habitat types (i.e., in the lake, adjacent to spring-fed bogs, and along irrigation canals). The type is extensive around the entire shoreline

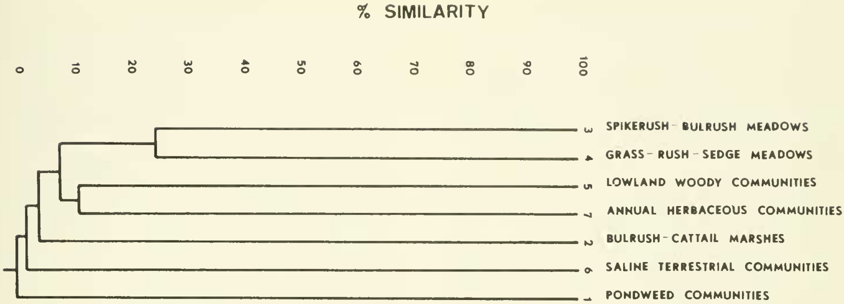

Fig. 2. Community similarity analysis reported as a cluster diagram based on plant composition of the Utah Lake communities.

of the lake, but reaches maximum development in Provo Bay and Powell's Slough.

Whether *Scirpus acutus* or *Typha latifolia* dominates any particular marsh seems to be largely a matter of priority, according to Cottam (1926). This observation tends to support the concept that the subcommunities defined by Coombs (1970) can be partially accounted for by patterns in asexual reproduction of the dominant species.

Spikerush-Bulrush Meadows

The spikerush-bulrush meadow communities are generally situated in areas that are inundated in the early seasons of the year but dry by September. The soil of the community varies but generally consists of peaty sandy loams (Coombs 1970). Organic matter content of the soil is high and, in places, the community occurs on peat beds that are 30 inches deep. The type averaged 17 species per stand; several species share dominance. The two most important species are *Eleocharis macrostachya* and *Carex nebrascensis* (Table 5). The community is restricted to the eastern side of the lake extending from near White Lake in Goshen Bay to the Jordan River, but is best developed in Benjamin's Slough and Provo Bay. The major component species appear to distribute themselves in predictable ways in space—as subdominants of the community. *Scirpus validus* for example, is often found in nearly pure stands surrounded by mixed zones of *Eleochraris macrostachya* and *Carex nebraskensis.* These latter species generally give way to areas dominated by *Distichlis stricta.* The relationship appears to be associated with a water gradient in which moisture increases as one moves toward areas dominated by *Scirpus validus* (Coombs 1970). Again one sees local areas dominated by single species that reproduce vigorously by asexual processes.

Grass-Rush-Sedge Meadows

The grass-rush-sedge meadows inhabit the largest area of any of the semiaquatic herbaceous communities described thus far. They are situated geographically much like the spikerush-bulrush meadows, but tend to differ in at least the following ways: (1) although seasonally saturated the excess water has generally drained away by late spring, (2) the soils generally are less peaty, and (3) the soils are often slightly to moderately saline.

This community shows the greatest internal variation and as a result exhibits the highest mean diversity value (Table 3), which is exceeded only by the annual herbaceous communities. The community averaged 18 species per study unit and is the only community dominated by grass (Table 6). Of the 8 most important species, 6 are considered to be salt tolerant. The community is extensive (found throughout the study area) and often occupies sites lying between upland shrub types and the communities already described. There is a great deal of subdominant variation within the type that appears to reflect patterns of asexual reproduction on the one hand and islands of local habitat variation on the other (i.e., pockets of peat loam soil dominated by *Carex nebraskensis*, etc.). Again, the major dominants and subdominants segregate along a moisture gradient. The sedges (*Scirpus americanus*, *Eleocharis macrostachya*, and *Carex nebraskensis*) tend to be dominant on those areas of seasonal inundation, and the grasses (*Distichlis stricta*, *Hordeum jubatum*, and *Sporobolus aeroides*) tend to dominate the higher dryer areas.

Lowland Woody Communities

The lowland woody community is a broadly scattered type occupying a variety of disjunct sites about the lake. It is among the three most extensive communities surrounding the lake and is found most often in seasonally submerged sites often near flowing streams. The soils are predominantly mineral (sandy to sandy clay loams) with varying degrees of incorporated organic matter. The community averaged only 9 species per stand (Table 7) and yielded one of the lowest diversity indices (Table 3). Of the woody dominants listed, 3 are shrubs and 2 are trees. There are two layers in the community, the tree-shrub overstory and a grass-annual or aquatic herb understory. The aquatic herbaceous understory is important only in areas where willows are dominant. There is a high degree of subdominant variation and internal heterogeneity in the community. However, in this case, as opposed to previous described types, the majority of the variation is due to habitat differences rather than asexual reproductive patterns.

Tamarix ramosissima and *Elaeagnus angustifolia*, two of the most important species listed (Table 7), are exotic invaders. Since they occur in the overstory and since *T. ramosissima* is the most widely distributed plant in the type, it appears that this type has been more extensively modified by human activities than any other community considered here. Coombs (1970) considered both species to be increasing and suggested that much of the woodland community is in various stages of recovery from disturbance. If his evaluation is accurate, it appears that the woodland community will undergo a great deal of change in the future.

Saline Terrestrial Community

The saline terrestrial community is the most geographically restricted type discussed thus far. It is essentially confined to Benjamin's Slough, Goshen Bay, and surrounding areas. The soils vary from sandy clay loams to heavy clays and are generally poorly drained and alkaline or saline in nature. Soil erosion is often evident and disturbance from several sources is generally apparent. Salt content in the soil varies greatly in both lateral and vertical space. Variation in salinity combines with variation in soil moisture and local topography to produce small scale heterogeneity in the vegetation. The soils in many areas are seasonally wet, but the communities are not required to develop under water.

Small drainage basins are scattered throughout the type and act as receptacles of spring runoff. As the trapped water evaporates from these catchment basins, salts and other materials carried there by the water are left behind. Salt pans or playas develop in such areas. It is around such playa areas that a majority of the vegetational variation is found. This variation is accounted for by concentric rings of vegetation that surround the playas. Terrestrial saline communities are low in species diversity (Table 3) and average only five species per stand (Table 8). Of the dominants listed, all are salt tolerant and two (i.e. *Kochia americana* and *Suaeda nigra*) are considered to be disturbance indicators (Coombs 1970).

Annual Herbaceous Communities

The annual herbaceous type is a conglomeration of several terrestrial communities that occupy waste places around the lake. These areas often have little in common and exhibit high variability in environment and species composition. Because of great environmental variability and regular disturbance, such as along beaches, seasonally inundated islands, and areas heavily impacted by the activities of man, the communities often remain in early seral stages of succession. This is evidenced by the fact that most of the dominant species (Table 9) are of the annual life form, a life-style that permits plants to complete their life cycle in a few months. Since variation is great and conditions change from year to year, patterns in species dominance also fluctuate annually. Stability will only come to these communities as environmental predictability increases.

Ecological Relationships

Total Cover

Total cover in the communities surrounding Utah Lake varies from 9.8 percent in the pondweed sites to 76.6 percent in the Grass-rush-sedge meadows (Table 3). Observed differences appear to be related to variations in moisture (Fig. 3). As seen in Figure 3, the largest cover values occur midway along the moisture gradient in communities that tend to exhibit the most favorable soil moisture regimes. When there is either too much moisture (year-round inundation) or too little moisture (dry upland sites), fewer plants appear to perform well, thus lowering cover values in these areas.

Asexual Reproduction

As previously suggested, much of the subcommunity variation with the aquatic and semiaquatic communities of Utah Lake can be related to asexual reproduction by dominant species. This seems especially true in those communities that are continuously or seasonally inundated for long periods. Figure 4 illustrates this relationship. Communities having dominant species that reproduce asexually are also those communities common to the wet end of the moisture gradient. This being the case, it appears that those habitats with the most uniform moisture conditions tend to select for species capable of asexual reproduction and against species incapable of such reproduction methods.

Intracommunity Similarity

Earlier in this paper reference has been made of the subcommunity (within) variations in each of the seven major community types. Such internal variations can be measured with similarity indices. I have computed a similarity index matrix (Runzicka 1958) utilizing all stands in each community. Thus, the similarity of each stand with all other stands of a community is obtained. All similarity indices in each community matrix is finally averaged to obtain a mean and standard deviation for internal similarity of each community type. The larger the value the more internally similar is the community; conversely, the lower the value the greater the internal variability. Variation in intracommunity similarity is plotted against variation in available moisture for growth in Figure 5. Intracommunity variation is seen to increase as moisture variability increases. This indicates that as habitat predictability decreases, the composition of communities occupying such habitats also becomes more variable and less recognizable as distinct entities.

Life Forms

The relationship of plant life forms to environmental factors has been the concern of

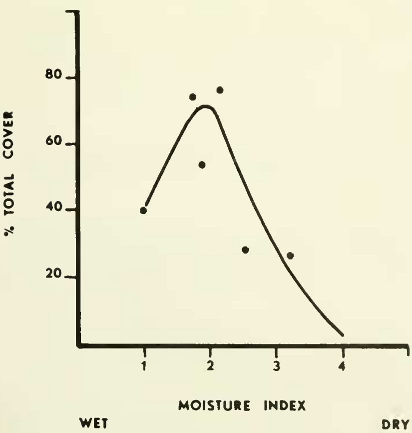

Fig. 3. Total living cover in the Utah Lake communities in relationship to changing moisture conditions.

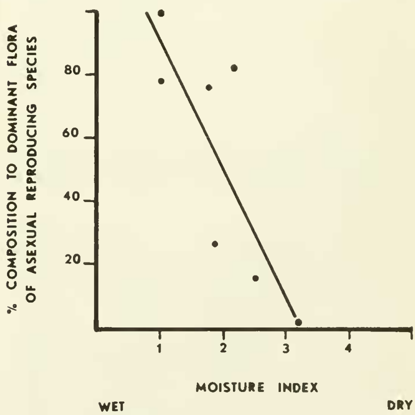

Fig. 4. Importance of asexual reproducing species in the Utah Lake communities as moisture becomes less available.

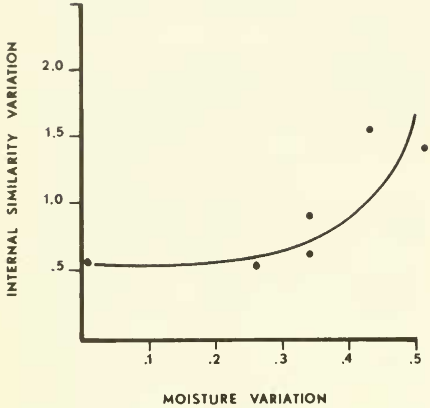

Fig. 5. Variation in internal community similarity as moisture variation increases.

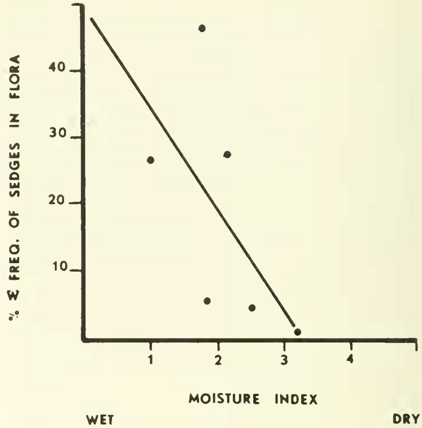

Fig. 7. Importance of sedges in Utah Lake communities in relationship to changing moisture conditions.

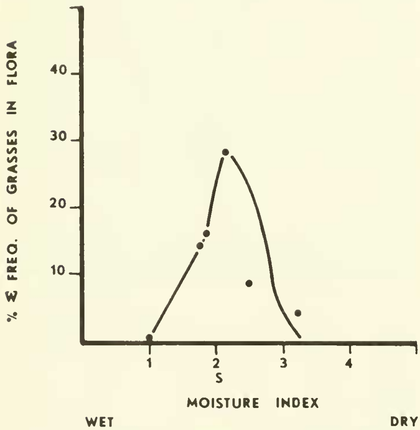

Fig. 6. Importance of grasses in the Utah Lake communities in relationship to changing moisture conditions.

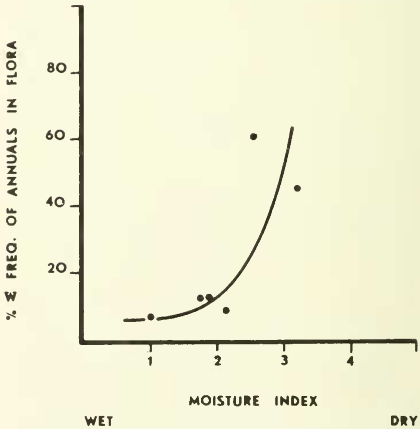

Fig. 8. Importance of annuals in the communities of Utah Lake in relationship to changing moisture conditions.

ecologists for many years. The life form concept was useful in this paper in delimiting community types (i.e., grass-rush-sedge meadows, lowland woody communities, or annual herbaceous communities). The concept also helps relate environmental pattern to plant response in the habitat complex of Utah Lake (Table 3, Figs. 6–10). The data demonstrate that some of the life form classes exhibit rather distinct responses to moisture patterns around the lake. Grasses, for example, do best in habitats with moisture regimes midway along the gradient (Fig. 6). In contrast, the sedges are most abundant at the higher moisture levels (Fig. 7). Annuals reach their greatest importance in the driest habitats (Fig. 8). With respect to annuals, the relationships depicted by Figures 9 and 10 are also of interest. As shown, the annual life form does especially well in habitats that are open, low in cover, and support a good deal of exposed soil. In such areas, interspecific competition

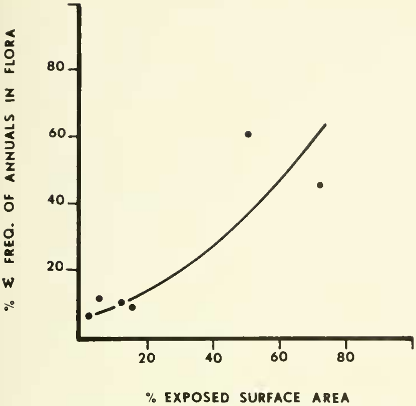

Fig. 9. Importance of annuals in the communities of Utah Lake in relationship to percent exposed surface area.

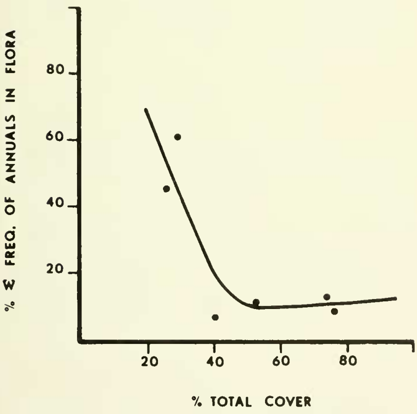

Fig. 10. Importance of annuals in the communities of Utah Lake in relationship to total living cover.

is low, thus giving species which by life-style must complete the life cycle in one season the maximum opportunity to do so.

Introduced Exotics

Species distribution patterns vary greatly in nature; however, in many cases the range of a species tends to be confined to a well-defined geographical region. Should a species jump the barriers confining it to its original range and invade another ecosystem else-

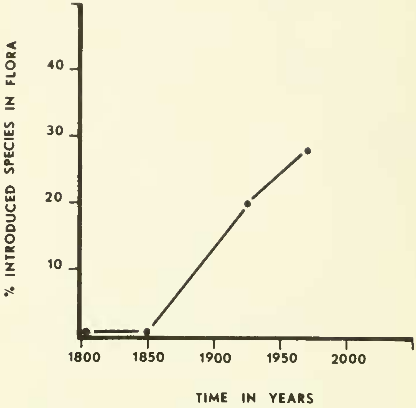

Fig. 11. Increased importance of introduced species in Utah Lake flora since the early 1800s.

where, it becomes a foreign element in that community and is classed as an introduced or exotic species. Historically, many such species have entered the vegetation surrounding Utah Lake (Fig. 11). Cottam (1926) completed the first real quantitative work on the vegetation of Utah Lake. He listed 333 species in the flora, 67 of which (20 percent) were introduced. Coombs (1970) quantitatively studied the same area. He observed 305 species in the flora, 84 of which were introduced (27 percent).

Ecologically, introduced species may (1) invade native ecosystems and cause unexpected consequences of a harmful or disruptive nature, (2) invade and increase the complexity of existent ecosystems and become useful (nondisruptive) components of such communities, (3) become marginally established and exhibit no apparent effect on the original system, or (4) fail to become established. In the case of the communities around Utah Lake, one can find examples of species that fill all the above categories. However, only a few species (i.e., *Tamarix ramosissima, Elaeagnus angustifolia, Bromus tectorum, Trifolium hybridum, Atriplex hortensis, Polygonum lapathifolium,* and *Malva neglecta,* etc.) have become major influences in these natural communities. If the distribution patterns of the introduced species of the communities studied in the interest of habitat

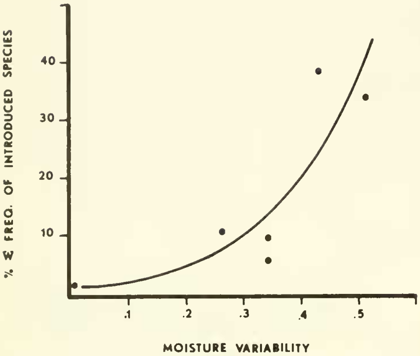

Fig. 12. Importance of introduced species in the communities of Utah Lake as moisture variability increases.

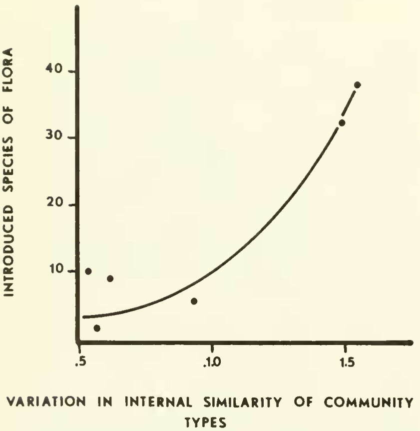

Fig. 13. Importance of introduced species in the Utah Lake communities as internal community similarity increases.

conditions surrounding the lake are considered, two important relationships emerge (Figs. 12 and 13). First, as shown in Figure 12, the introduced species reach their greatest development in those habitats that show the greatest variability in moisture (the most unpredictable environments); and second (Fig. 13), those communities having the greatest internal variation in composition tend to be the most easily invaded. Undoubtedly, such communities have structural gaps that allow a species entering from the outside to become established and compete successfully. These gaps would almost certainly arise as a result of interaction between moisture variability and the resultant effect it has on internal community structure.

Table 10. Plant families contributing the majority of species to the flora of Utah Lake.

Family	Percent of species
Asteraceae	16.7
Poaceae	14.5
Cyperaceae	6.3
Chenopodiaceae	5.9
Cruciferae	5.9
Leguminosae	3.9
Polygonaceae	2.9
Rosaceae	2.9
Labiatae	2.5
Salicaceae	2.2
Scrophulariaceae	2.2
Onagraceae	2.0
Total	67.9

Floristic Relationships

A total of 483 species of vascular plants, representing 275 genera, and 74 families was observed and/or found recorded as belonging to the plant communities of Utah Lake. Of these, 67.9 percent belonged to 12 plant families (Table 10). The ecological or phytogeographical significance of the dominance of these families (Table 10) is not known, but further investigations along such lines should hold great interest.

ACERACEAE
Acer grandidentatum Nutt.
Acer negundo L.

AIZOACEAE
Sesuvium verrucosum Raf.

ALISMATACEAE
Alisma triviale Pursh
Sagittaria cuneata Sheld.

AMARANTHACEAE
Amaranthus graecizans L.
Amaranthus retroflexus L.

ANACARDIACEAE
Rhus radicans L.
Rhus trilobata Nutt.

APOCYNACEAE
Apocynum cannabinum L. var. *glaberrimum* A.DC.

ASCLEPIADACEAE
Asclepias incarnata L.
Asclepias speciosa Torr.

ASTERACEAE
Achillea millefolium L.
Ambrosia artemisiifolia L.
Ambrosia psilostachya DC.
Anthemis cotula L.
Arctium minus Schk.
Artemisia absinthium L.
Artemisia dracunculus L.
Artemisia ludoviciana Nutt.
Artemisia spinescens D.C. Eaton
Artemisia tridentata Nutt.
Aster brachyactis Blake
Aster chilensis Nees ssp. *adscendens* (Lindl.) Cronq.
Aster eatonii (A. Gray) Howell
Aster frondosus (Nutt.) Torr. & Gray
Aster perelegans A. Nels. & Macbr.
Balsamorhiza hookeri Nutt.
Bidens cernua L.
Bidens frondosa L.
Chaenactis douglasii H. & A.
Chrysopsis villosa (Pursh) Nutt. var. *foliosa* (Nutt.) D.C. Eaton
Chrysothamnus nauseosus (Pall.) Britt.
Chrysothamnus viscidiflorus (Hook.) Nutt.
Cichorium intybus L.
Cirsium arvense (L.) Scop.
Cirisium foliosum (Hook.) DC.
Cirsium undulatum (Nutt.) Spreng.
Cirsium vulgare (Savi) Airy-Shaw
Conyza candensis (L.) Cronq.
Crepis modocensis Greene
Crepis runcinata (James) Torr. & Gray
Erigeron bellidiastrum var. *typicus* Cronq.
Erigeron divergens Torr. & Gray
Erigeron glabellus Nutt.
Erigeron lonchophyllus Hook.
Eupatorium maculatum L.
Franseria acanthicarpa (Hook.) Cov.
Gnaphalium chilense Spreng.
Gnaphalium palustre Nutt.
Grendelia squarrosa (Pursh) Donal
Haplopappus lanceolatus (Hook.) Torr. & Gray
Haplopappus watsoni A. Gray
Helenium autumnale D.C. Eaton
Helianthus annuus L.
Helianthus nuttallii Torr. & Gray
Helianthus petiolaris Nutt.
Hieracium gracile Hook.
Hymenoxys acaulis (Pursh) Parker
Inula helenium L.
Iva axillaris Pursh
Iva xanthifolia Nutt.
Lactuca pulchella (Pursh) DC.
Lactuca scariola L.
Laphamia stansburii A. Gray
Layia glandulosa (Hook.) Hook. & Arn.
Lygodesmia grandiflora (Nutt.) Torr. & Gray
Machaeranthera tanacetifolia (HBK.) Ness
Matricaria matricarioides (Less.) Porter
Senecio hydrophilus Nutt.
Senecio uintahensis (A. Nels.) Greene
Solidago canadensis L.
Solidago occidentalis (Nutt.) Torr. & Gray
Sonchus arvensis L.
Sonchus asper (L.) Hill
Stephanomeria pauciflora (Torr.) Nutt.
Tanacetum vulgare L.
Taraxacum officinale Weber
Tetradymia glabrata A. Gray
Tetradymia spinosa Hook. & Arn.
Townsendia florifer (Hook.) A. Gray
Townsendia strigosa Nutt.
Tragopogon dubius Scop.
Tragopogon porrifolius L.
Viguiera ciliata (Robins. & Greenm.) Blake
Viguiera multiflora (Nutt.) Blake
Wyethia amplexicaulis (Nutt.) Nutt.
Xanthium strumarium L.
Xanthocephalum sarothrae (Pursh) Shinners

BETULACEAE
Alnus tenuifolia Nutt.
Betula occidentalis Hook.

BORAGINACEAE
Cryptantha flavoculata (A. Nels.) Payson
Cryptantha nana (Eastw.) Payson
Cynoglossum officinalis L.
Heliotropium curassavicum L.
Lappula redowskii (Hornem.) Greene
Lithospermum ruderale Doug. ex Lehm.
Plagiobothrys scouleri (Hook. & Arn.) I.M.

CACTACEAE
Echinocactus simpsonii Engelm.
Echinocereus triglochidiatus Engelm. var. melanacanthus (Engelm.) L. Benson
Opuntia fragilis (Nutt.) Haw.
Opuntia polycantha Haw.

CAPPARIDACEAE
Cleome lutea Hook.
Cleome serrulata Pursh
Polanisia dodecandra (L.) DC.

CAPRIFOLIACEAE
Lonicera involucrata (Rich.) Banks

CARYOPHYLLACEAE
Cerastium vulgatum L.
Saponaria officinalis L.
Spergularia marina (L.) Griseb.

CERATOPHYLLACEAE
Ceratophyllum demersum L.

CHENOPODIACEAE
Allenrolfea occidentalis (S. Wats.) Kuntze
Atriplex confertifolia (Torr. & Frem.) S. Wats
Atriplex heterosperma Bunge
Atriplex hortensis L.

Atriplex patula var. *hastata* (L.) A. Gray
Atriplex tridentata Kuntze
Ceratoides lanata (Pursh) J. T. Howell
Chenopodium album L.
Chenopodium chenopodiodes (L.) Aellen
Chenopodium fremontii S. Wats.
Chenopodium gigantospermum Aellen
Chenopodium glaucum L.
Chenopodium leptophyllum Nutt.
Chenopodium murale L.
Chenopodium watsoni A. Nels.
Corispermum villosum Rydb.
Echinopsilon hyssopifolium (Pall.) Moq.
Grayia spinosa (Hook.) Moq.
Hologeton glomeratus (Bieb.) Mey.
Kochia americana S. Wats.
Kochia scoparia (L.) Schard.
Monolepis nuttalliana (Schult.) Greene
Salicornia pacifica Standl.
Salicornia rubra A. Nels.
Salsola iberica Senner & Pan.
Sarcobatus vermiculatus (Hook.) Torr.
Suaeda depressa (Pursh) S. Wats.
Suaeda fruticosa (L.) Forsk.
Suaeda nigra (Raf.) J. F. Macbride
Suaeda occidentalis S. Wats.

CONVOLVULACEAE
Convolvulus arvensis L.
Convolvulus sepium L.
Cressa truxillensis H.B.K.
Cuscuta salina Engelm.

CORNACEAE
Cornus stolonifera Michx.

CRUCIFERAE
Arabis glabra (L.) Bernh.
Arabis holboellii Hornem.
Brassica campestris L.
Brassica kaber (D.C.) Wheeler var. *pinnatifida*
Brassica nigra (L.) Koch
Camelina microcarpa Andrz.
Capsella bursa-pastoris (L.) Medic.
Cardamine pennsylvanica Muhl. ex Willd.
Cardaria draba (L.) Desv.
Conringia orientalis (L.) Dumort
Descurainia pinnata (Walt.) Britt.
Descurainia sophia (L.) Webb.
Erysimum capitatum (Dougl.) Greene
Erysimum inconspicuum (S. Wats.) Mac M.
Erysimum repandum L.
Hutchinsia procumbens (L.) Desv.
Lepidium densiflorum Schrad.
Lepidium densiflorum var. *ramosum* (A. Nels.) Thell.
Lepidium montanum Nutt.
Lepidium perfoliatum L.
Lepidium virginicum L.
Malcolmia africana (L.) R. Br.
Nasturtium officinale R. Br. in Ait.
Physaria australis (Payson) Rollins
Rorippa islandica (oed.) Borbas
Sisymbrium altissimum L.
Stanleyella wrightii (A. Gray) Rydb.
Streptanthus cordatus Nutt. ex Torr. & Gray
Thelypodium sagittatum (Nutt.) Endl.

CUPRESSACEAE
Juniperus osteosperma (Torr.) Little

CYPERACEAE
Carex aurea Nutt.
Carex aquatilis Wahl.
Carex atherodes Spreng.
Carex lanuginosa Michx.
Carex nebraskensis Dewey
Carex petasata Dewey
Carex praegracilis W. Boott.
Cyperus erythrorhizos Muhl.
Cyperus strigosus L.
Eleocharis acicularis (L.) Roem. & Schult.
Eleocharis bolanderi A. Gray
Eleocharis palustris (L.) Roemer & Scultes
Eleocharis parvula (Roem. and Schult.) Link. var. *coloradensis* (Britton) Beetle
Eleocharis pauciflora (Lightf.) Link.
Eleocharis rostellata Torr.
Fimbristylis spadicea (L.) Vahl.
Scirpus acutus Muhl.
Scirpus americanus Pers.
Scirpus lacustris L.
Scirpus maritimus L.
Scirpus microcarpus Presl.
Scirpus pallidus (Britton) Fernald
Scirpus validus Vahl.

DIPSACACEAE
Dipsacus sylvestris Huds.

ELAEAGNACEAE
Elaeagnus angustifolia L.
Shepherdia argentea (Pursh) Nutt.

EPHEDRACEAE
Ephedra viridis Coville

EQUISETACEAE
Equisetum arvense L.
Equisetum kansanum Schaffn.
Equisetum laevigatum A. Br.
Equisetum palustre L.

EUPHORBIACEAE
Euphorbia glyptosperma Engelm. ex Emory
Euphorbia serpyllifolia Pers.

FUMARIACEAE
Corydalis aurea Willd.

GENTIANACEAE
Centaurium exaltatum (Griseb.) Wight

GERANIACEAE
Erodium cicutarium (L.) L'Her.

HALORAGACEAE
Hippurus vulgaris L.
Myriophyllum spicatum L.

HYDROCHARITACEAE
Elodea canadensis Michx.

IRIDACEAE
Sisyrinchium halophilum Greene

JUNCACEAE
Juncus balticus Willd.
Juncus bufonius L.
Juncus ensifolius Wikstr.
Juncus longistylis Torr.
Juncus torreyi Coville

JUNCAGINACEAE
Triglochin maritima L.

LABIATAE
Lamium amplexicaule L.
Lycopus americanus Muhl. ex Bart.
Lycopus lucidus Turcz.
Marrubium vulgare L.
Mentha arvensis L.
Mentha spicata L.
Moldavica parviflora (Nutt.) Britt.
Nepeta cataria L.
Stachys palustris L.
Teucrium canadense L. var. *occidentale* (A. Gray) McClintock & Epling

LEGUMINOSAE
Astragalus argophyllus Nutt. var. *argophyllus*
Astragalus beckwethii Torr. & Gray
Astragalus canadensis L.
Astragalus convallarius Greene
Astragalus oophorus S. Wats.
Astragalus utahensis (Torr.) Torr. & Gray
Glycyrrhiza lepidota Pursh
Hedysarum boreale Nutt.
Lathyrus brachycalyx Rydb.
Medicago lupulina L.
Medicago sativa L.
Melilotus alba Descr.
Melilotus officinalis (L.) Lam.
Robinia pseudo-acacia L.
Thermopsis montana Nutt.
Trifolium hybridum L.
Trifolium pratense L.
Trifolium repens L.
Vicia americana Muhl. var. *minor* Hook.

LEMNACEAE
Lemna minor L.
Lemna trisulca L.
Lemna valdiviana Phil
Spirodela polyrhiza (L.) Schleid.

LENTIBULARIACEAE
Utricularia minor L.

LILIACEAE
Allium acuminatum Hook.
Asparagus officinalis L.
Smilacina stellata (L.) Desf.

LOASACEAE
Mentzelia albicaulis Dougl. ex Hook.
Mentzelia decapetala (Pursh) Urb. & Gilg.
Mentzelia laevicaulis (Dougl.) Torr. & Gray
Mentzelia multiflora (Nutt.) A. Gray

LYTHRACEAE
Lythrum salicaria L.

MALVACEAE
Althaea rosea Cav.
Malva neglecta Wallr.
Sida hederacea (Dougl.) Torr.
Sidalcea neomexicana A. Grey
Sidalcea oregana (Nutt.) A. Gray
Sphaeralcea coccinea (Pursh) Rydb.
Sphaeralcea grossulariaefolia (H. & A.) Rydb.
Sphaeralcea munroana (Dougl.) Spach

MORACEAE
Morus rubra L.

NYCTAGINACEAE
Abronia salsa Rydb.

NYMPHAECEAE
Nuphar polysepalum Engelm.

OLEACEAE
Fraxinus velutina Torr.

ONAGRACEAE
Epilobium adenocaulon Hausskn.
Epilobium paniculatum Nutt. ex Torr. & Gray
Gaura parviflora Dougl.
Oenothera alyssoides Hook. & Arn.
Oenothera caespitosa Nutt.
Oenothera hookeri Torr. & Gray
Oenothera latifolia (Rydb.) Munz
Oenothera minor (A. Nels.) Munz
Oenothera pallida Lindl.
Oenothera scapoidea Torr. & Gray ssp. *utahensis* Raven

ORCHIDACEAE
Cypripedium calceolus L. var. *pubescens* (Willd.) Cornell
Epipactis gigantea Dougl.
Spiranthes romanzoffiana Cham. & Schl.

OROBANCHACEAE
Orobanche multiflora Nutt.

PAPAVERACEAE
Argemone munita Dur. and Hilg.

PLANTAGINACEAE
Plantago lanceolata L.
Plantago major L.
Plantago patagonica Jacq.

POACEAE
Agropyron cristatum (L.) Gaertn.
Agropyron dasystachyum Scribn. (Hook.)
Agropyron elongatum (Host.) Beauv.

Agropyron intermedium (Host) Beauv.
Agropyron repens (L.) Beauv.
Agropyron smithii Rydb.
Agropyron spicatum (Pursh) Scribn. & Smith
Agropyron trachycaulum (Link) Malte.
Agrostis semiverticillata (Forsk.)
Agrostis stolonifera L.
Alopecurus aequalis Sobol.
Avena fatua L.
Avena sativa L.
Beckmannia syzigachne (Steud.) Fern.
Bromus commutatus Schrad.
Bromus inermis Leyss.
Bromus tectorum L.
Calamagrostis canadensis (Michx.) Beauv.
Calamagrostis neglecta (Ehrh.) Gaertn. Mey & Schreb.
Catabrosa aquatica (L.) Beauv.
Cenchrus tribuloides L.
Dactylis glomerata L.
Deschampsia caespitosa (L.) Beauv.
Distichlis spicata (L.) Green
Echinochloa crusgalli (L.) Beauv.
Elymus canadensis L. Michx.
Elymus cinereus Scribn. & Merr.
Elymus simplex Scribn. & Williams
Elymus tritiocides Buckl.
Elymus virginicus L. var. *submuticus* Hook.
Eragrostis cilianensis (All.) Mosher
Eragrostis hypnoides (Lam.) Britton, Sterns, & Poggenb.
Eragrostis orcuttiana Vasey
Festuca pratensis Huds.
Glyceria grandis S. Wats.
Hordeum brachyantherum Nevski
Hordeum jubatum L.
Hordeum leporinum Link.
Leersia oryzoides (L.) Swantz
Leptochloa fascicularis (Lam.) A. Gray
Lolium multiflorum Lam.
Muhlenbergia asperifolia (Nees & Meyen) Parodi
Oryzopsis hymenoides (R. & S.) Riker
Panicum capillare L.
Panicum capillare L. var. *occidentale* Rydb.
Phalaris arundinacea L.
Phleum pratense L.
Phragmities australis (Cav.) Trin. ex Stendel
Poa annua L.
Poa navadensis Vasey ex Scribn.
Poa pratensis L.
Polypogon monspeliensis (L.) Desf.
Puccinellia nuttalliana (J.A. Schultes) A.S. Hitchc.
Sclerochloa dura (L.) Beauv.
Secale cereale L.
Setaria glauca (L.) Beauv.
Setaria viridis (L.) Beauv.
Sitanion hystrix (Nutt.) J. G. Smith
Sitanion jubatum J. G. Smith
Spartina gracilis Trin.
Sphenopholis obtusata (Michx.) Scribn.
Sporobolus airoides (Torn) Torr.
Sporobolus asper (Michx.) Kunth
Sporobolus cryptandrus (Torr.) A. Gray
Stipa comata Trin. & Rupr.
Triticum aestivum L.
Vulpia octoflora (Walter) Rydb.

POLEMONIACEAE
Collomia linearis Nutt.
Gilia aggregata (Pursh) Spreng.
Gilia inconspicua (Smith) Sweet
Gilia leptomeria A. Gray
Gilia tenerrima A. Gray
Phlox austromontana Coville
Phlox longifolia Nutt.
Polemonium micranthum Benth.
Polemonium occidentale Greene

POLYGONACEAE
Eriogonum effusum Nutt.
Eriogonum racemosum Nutt.
Eriogonum umbellatum Torr.
Polygonum amphibium L.
Polygonum aviculare L.
Polygonum coccineum Muhl. ex Willd.
Polygonum convolvulus L.
Polygonum lapathifolium L.
Polygonum pennsylvanicum L.
Polygonum persicaria L.
Polygonum ramosissimum Michx.
Rumex crispus L.
Rumex fueginus Phil.
Rumex venosus Pursh

PORTULACACEAE
Portulaca oleracea L.

POTAMOGETONACEAE
Potamogeton crispus L.
Potomogeton filiformis Pers.
Potamogeton foliosus Raf.
Potamogeton nodosus Poir. ex Lam.
Potamogeton pectinatus L.
Potamogeton praelongus Wulf.

PRIMULACEAE
Dodecatheon pulchellum (Raf.) Merrill
Glaux maritima L.
Steironema ciliatum (L.) Raf.

RANUNCULACEAE
Delphinium andersoni A. Gray
Ranunculus acris L.
Ranunculus aquatilis L. *capillaceus* (Thuill.) DC.
Ranunculus circinatus Sibth.
Ranunculus cymbalaria Pursh
Ranunculus macounii Britton
Ranunculus oreogenes Greene
Ranunculus testiculatus Crantz

ROSACEAE
Amelanchier alnifolia (Nutt.) Nutt.
Amelanchier utahensis Koehne
Cowania mexicana D. Don
Crataegus douglasii Lindl. var. *rivularis* (Nutt.) Sarg.
Potentilla anserina L.
Potentilla biennis Greene
Potentilla glandulosa Lindl.
Potentilla gracilis Dougl. var. *elmeri* (Rydb.) Jeps.
Potentilla paradoxa Nutt.
Prunus americana Marsh
Prunus virginiana L. var. *melanocarpa* (A. Nels.) Sarg.

Purshia tridentata (Pursh) DC.
Rosa nutkana Presl.
Rosa woodsii Lindl.

RUBIACEAE
Galium trifidum L.

RUPPIACEAE
Ruppia maritima L.

SALICACEAE
Populus alba L.
Populus angustifolia James
Populus deltoides Bartr.
Populus fremontii S. Wats.
Populus nigra L. var. *italica* Muenchh.
Populus trichocarpa Torr. & Gray
Salix amygdaloides Anders.
Salix exigua Nutt.
Salix fragilis L.
Salix lasiandra Benth.
Salix rigida Muhl.

SALVINIACEAE
Azolla caroliniana Willd.
Salvinia rotundifolia Willd.

SANTALACEAE
Comandra pallida A. DC.

SAXIFRAGACEAE
Heuchera parvifolia Nutt. ex Torr. & Gray
Ribes aureum Pursh

SCROPHULARIACEAE
Castilleja chromosa A. Nels.
Castilleja exilis A. Nels.
Castilleja minor (A. Gray) A. Gray
Collinsia grandiflora Dougl.
Cordylanthus canescens A. Gray
Mimulus glabratus HBK
Mimulus guttatus DC.
Penstemon humilis Nutt. ex A. Gray
Verbascum thapsus L.
Veronica americana Schwein
Veronica anagallis-aquatica L.
Veronica hederaefolia L.
Veronica peregrina L.

SOLANACEAE
Lycium halimifolium Mill.
Physalis longifolia Nutt.
Solanum dulcamara L.
Solanum nigrum L.
Solanum triflorum Nutt.

SPARGANIACEAE
Sparganium emersum Rehmann
Sparganium eurycarpum Engelm.

TAMARICACEAE
Tamarix ramosissima Ledeb.

THYPACEAE
Typha angustifolia L.
Typha latifolia L.

ULMACEAE
Celtis reticulata Torr.
Ulmus americana L.
Ulmus pumila L.

UMBELLIFERAE
Berula erecta (Huds.) Coville
Cicuta douglasii (DC.) Coult. & Rose
Conium maculatum L.
Pastinaca sativa L.
Sium suave Walt.

URTICACEAE
Urtica dioica L. var *procera* (Muhl.) Wedd.
Urtica serra Blume

VERBENACEAE
Verbena bracteata Lag. and Rodr.
Verbena hastata L.
Verbena stricta Vent.

VIOLACEAE
Viola nephrophylla Greene

ZANNICHELLIACEAE
Zannichellia palustris L.

ZYGOPHYLLACEAE
Tribulus terrestris L.

Species included in the literature as being present in the Utah Lake flora but for which there is not any evidence that such is the case.

Amaranthus lividus L.
Camelina sativa (L.) Crantz.
Carex aperta Boott.
Cenchrus tribuloides L.
Erigeron annuus (L.) Pers.
Gnaphalium occidentalis Nutt.
Lepidium ramosissimum A. Nels.
Mirabilis linearis (Pursh) Heimerl.
Sagittaria graminea Michx.
Scirpus nebraskensis L.

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